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HUMAN CAPABILITIES IN THE PRONE AND SUPINE POSITIONS: AN ANNOTATED BIBLIOGRAPHY

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ABSTRACT

This literature search covers the decade, 1951-1961. It is concerned with the ability of man to perform basic operations in aircraft while relegated to a prone or supine position, and the possible application of man's performance in spacecraft under similar conditions. References to the design requirements for man are included.

In addition to the current acquisitions of the Lockheed Missiles and Space Company Technical Information Center and certain specialized journals, the following sources were surveyed in the preparation of this bibliography:

Aero/Space Engineering, 1959-1960

Aerospace Medicine: abstracts of current literature, 1959-1961

Annotated Bibliography of Applied Physical Anthropology in Human Engineering, 1958

Aviation Medicine: a Library of Congress bibliography, 1952-1955

Human Engineering Bibliography, 1955-1959

International Aerospace Abstracts, 1961

Journal of Aviation Medicine: abstracts of current literature, 1955-1958

Search completed December 1961

1. Anderton, D.A.

Will prone flight lick high g-loads?

AVIATION WEEK v. 57, n. 26, p. 21-22, 24-25, 29 Dec 1952.

The prone position of the pilot in high-speed airplanes has certain advantages (higher g-tolerance of the pilot, reduction of drag due to decrease of frontal area, improved instrument visibility) and drawbacks (narrowing of field of vision, decrease of visual acuity, aggravation of claustrophobic tendencies, discomfort encountered in this abnormal position). A nylon bed designed in 1948 by the Aero Medical Laboratory was tested for 8 to 12 hours without apparent signs of discomfort. Three-dimensional hand control (i.e. operation of all the control surfaces by hand motions only) likewise gave good test results. Restriction of vision (up to 35°) was one of the major complaints raised by the test pilots. --The paper concludes with a brief discussion of flight tests at accelerations of less than 1 g, as would be encountered in space flight. The prone pilot was instrumented for recording of heart rate and electrocardiagram. He was asked to shake his head and to nod during the runs at zero g. There were no ill effects following these movements, but after the subgravity flight there was frequent vertigo. Coordination was not impaired, although there was tendency to overreach.

2. Anonymous

Frone-cockpit lay out promotes fatigue.

AVIATION WEEK v. 64, n. 14, p. 47-49, 1956.

This article discusses a prone-cockpit layout developed by the Institute of Aviation, RAE, Farnborough, England which was recently used in a Gloster Meteor 8 test. vehicle. Information is presented on load factor tolerance of the prone pilot, effectiveness of control, pilot fatigue, visibility, and pilot escape. Detailed descriptions of the pilot bed and escape mechanisms are also given.

3. Anonymous

Prone position. U.S. AIR FORCE MEDICAL SERVICE DIGEST v. 3, n. 1, p. 26-27, 1952.

A study of visual problems related to prone position in flight is outlined, undertaken by the School of Aviation Medicine at Randolph Field, Texas (Project 21-24-011). Subjects were instructed to sight a target for the duration of one hour from a prone-position bed, with their heads fixed at 15, 20, 25, and 30° angles. A tendency of the eyes to deviate to a measurable degree when the head was elevated 15°, was observed, accompanied by a sensation of discomfort. Some subjects experience double or blurred vision, a disturbance which was alleviated by looking downward. A second group of subjects was tested to determine the range of side vision during elevation of the eyes. Lateral vision at elevated angles was limited due to the obstructive effect of the nose or eyebrows. The advisability of optical aids (mirrors, prisms, etc.) to substitute for elevated gaze is pointed out. For effective vision, pilots should limit their gaze to 20°.

4. Ballinger, E.R.

Human experiments in subgravity and prolonged acceleration. JOURNAL OF AVIATION MEDICINE v. 23, n. 4, p. 319-321, 372, Apr 1952.

Aviators were exposed to period of essentially zero gravity of 15 to 25 seconds duration (in a jet plane which was pulled up vertically and moved in a ballistic trajectory, with the power cut off). As long as the subjects were held in place by safety belts and could see their surroundings, they did not lose their orientation. Coordination of movements was almost unimpaired. In the pull-out maneuver (3-4 g), head motions frequently resulted in vertigo. --In another series of test, subjects in supine positions were exposed to prolonged accelerations on a centrifuge, simulating the take-off of a space rocket. Accelerations ranging between 3 g for 9 minutes 31 seconds and 10 g for 2 minutes 6 seconds were tolerated, some with transitory substernal or epigastric discomfort and shortness of breath. An acceleration of 8 g is considered most appropriate from both the physiological and mechanical standpoints.

5. Brown, C.W., et al
COMPARISON OF AIRCRAFT CONTROLS FOR PRONE AND SEATED POSITION IN THREE-DIMENSIONAL PURSUIT TASK. U.S. Air Force. Wright-Patterson Air Force Base, Dayton, Ohio. A.F. technical rept. no. 5956, Mar 50, 18p. ASTIA ATI-73 414

6. Brown, C.W., et al
MAGNITUDE OF FORCES WHICH MAY BE APPLIED BY THE PRONE PILOT TO AIRCRAFT CONTROL DEVICES. I. THREE-DIMENSIONAL HAND CONTROLS. U.S. Air Force. Wright-Patterson Air Force Base, Engineering Division, Ohio. Memorandum rept. MCREXD-694-4J, 4 Mar 49, 68p. ASTIA ATI 52 794

7. Brown, C.W., et al
MAGNITUDE OF FORCES WHICH MAY BE APPLIED BY THE PRONE PILOT TO AIRCRAFT CONTROL DEVICES. II. TWO-DIMENSIONAL HAND CONTROLS. U.S. Air Force. Wright-Patterson Air Force Base, Dayton, Ohio. A.F. technical rept. no. 5954, Oct 49, 19p. ASTIA ATI-72 377

8. Brown, C.W., et al
MAGNITUDE OF FORCES WHICH MAY BE APPLIED BY THE PRONE PILOT TO AIRCRAFT CONTROL DEVICES. III. FOOT CONTROLS. U.S. Air Force. Wright-Patterson Air Force Base, Dayton, Ohio. A.F. technical rept. no. 5955, Oct 49, 10p. ASTIA ATI 70 936

9. Clark, W.G. and Henry, J.P.
STUDIES ON LYING IN THE PRONE POSITION. University of Southern California, Aero Medical Lab., Los Angeles. National Research Council Committee on Medical Research no. 466, 20 Aug 54, n.p.

10. Clark, W.G., et al
STUDIES ON FLYING IN THE PRONE POSITION. U.S. Office of Scientific Research and Development, Washington 25, D.C. C.A.M. rept. no. 466, Aug 45, n.p. (Contract OEMcmr-288)

11. David, H.M.
Mice impacted to save astronauts. MISSILES AND ROCKETS v. 8, n. 16, p. 35, 17 Apr 1961.

11. (cont'd) Mice enclosed in plastic tubes and positioned so that they received the impact of the fall on their backs were loaded on a carriage and dropped to the bottom of an elevator shaft. Survival rates indicate that small, restrained animals can tolerate impact velocities of about 17-31 m.p.h. and decelerations of 650-1970 g. The tests gave evidence that animals receiving high g forces in the transverse position survive with the fewest injuries. Impact tolerance limit data will eventually be incorporated in the design of restraint and escape systems.

12. Dzendolet, E. and Rievley, J.F.

ABILITY TO APPLY CERTAIN TORQUES WHILE WEIGHTLESS. U.S. Air Force. Aero Medical Laboratory, Wright-Patterson Air Force Base, Ohio. Rept. no. WADC TR 59-94, Apr 59, 28p. (Project 7184, Task 71586)

This study first reviews the anthropological literature to determine the torques a man can apply under normal conditions. Three experiments were performed in order to determine these torques under frictionless conditions: 1) maximum torque person can exert while truing to supinate his hand, 2) reaction force to a torque applied to a handhold (pushes and pulls) with handled varied through four positions and 3) qualitative observations on person performing two simple mechanical acts. The values obtained empirically were compared to calculated values and the validity of predictions so based was indicated. Suggestions concerning optimum body positions, use and location of handholds, design of handtools, and so forth are made.

13. Eisen, L. and Zeigen, R.S.

A SUPINE SEAT FOR HIGH-STRESS TESTING OF PRIMATES. U.S. Air Force rept. no. WADC TR 59-165, Apr 59, 18p.

Discussion of design criteria for a supine seat and restraint harness with a surrounding enclosure to be used in high stress biological experiments with a monkey.

14. Emerson, G.O.

Pilot vision from the prone position in fighter aircraft. JOURNAL OF AVIATION MEDICINE v. 23, n. 6, p. 608-611, June 1952.

Prone position of the pilot of a fighter aircraft would enable him to withstand greater g forces; an aircraft built around the prone position could also be more efficient structurally and aerodynamically. The characteristics of the visual field of the pilot in prone position were studied. Three types of visual field may be distinguished: the foveal rotational field (the area in which an object may be brought on the fovea by movements of the eyes), the peripheral rotational field (the total perceptual area which may be reached by eye movements), and the area which may be perceived by rotation and angulation of the head. The sum of the two monocular foveal fields was found to be nearly the same as the binocular foveal field; the sum of the monocular peripheral fields, however, exceeded the binocular peripheral field.--Fatigue which develops in upward gaze is greatly reduced when there is a frequent downward gaze to the instruments.--The visual field in prone position is sufficient for non-combat flying; its deficiency in combat flying may be remedied with optical equipment (mirrors, periscope).

15. Gell, C.F.

MODIFICATION OF F7F, INSTALLATION OF SUPINE SEAT AND RELATED COMPONENTS, IN-FLIGHT EVALUATION OF THE SEAT. U.S. Naval Air Development Center. Aviation Medical Acceleration Laboratory, Johnsville, Pa. Rept. no. NADC-MA-L5208; Proj. rept. no. NM 001 060.01.02, 10 Dec 52, 5p. ASTIA AD-133 324

A supine seat was installed in an F7F fighter plane and tested. Its relatively small size, and points of constriction, as well as the lack of visibility and difficulty of escape it imposed, were found to be undesirable features. In flight, control of the plane was made possible by means of an autopilot (PI K) device allowing the pilot to change position if desired. Additional

15. (cont'd) tests on the human centrifuge are recommended to investigate the physiological implications of the supine seat under acceleration. It is further recommended that the assembly be modified for stick and rudder installation, improved instrument, visibility, and greater physical comfort.

16. Gell, C.F. and Hunter, H.N.

PHYSIOLOGICAL INVESTIGATION OF INCREASING RESISTANCE TO BLACKOUT BY PROGRESSIVE BACKWARD TILTING TO THE SUPINE POSITION.

U.S. Naval Air Development Center. Aviation Medical Acceleration Laboratory, Johnsville, Pa. Rept. no. NADC-MA-5406; Proj. rept. no. NM 001 060.01.03, 30 June 54, 26p. ASTIA AD-36 856 (Also In JOURNAL OF AVIATION MEDICINE v. 25, n. 6, p. 568-577, Dec 1954)

A reclining seat was constructed which is capable of being tilted backward and fixed at angles of 15, 25, 35, 45, 55, 65, 77 and 85 degrees from the vertical. The seat was attached to a human centrifuge, and six male subjects were exposed to 5-second runs from 1 g to the g level where gray-out occurred for each position. There was not increase in blackout tolerance until a backward tilt of 45° was reached, when the tolerance increase was of the order of $\frac{1}{4}$ g; the first significant increase occurred at 77°, where an increase tolerance of 2.5 g was noted. At the 85° tilt, two subjects were exposed to 10 transverse g for 5 seconds without reaching a gray-out. At 77° and above, tachycardia was recorded which was followed by a slower than normal pulse after the runs were completed; during deceleration, a relative bradycardia occurred. At 77° and above, ear pulse magnitude and ear opacity decreased; at 85°, ear opacity increased and the ear pulse magnitude first decreased and then increased. The most pronounced symptom which occurred at levels of supination greater than 65° was a pressure sensation in the thorax and abdomen.

17. Granath, A., Jonsson, B. and Strandell, T.

Studies on the central circulation at rest and during exercise in the supine and sitting body position in old men. ACTA MEDICA SCANDINAVICA v. 169, n. 1, p. 125-126, Jan 1961.

In an attempt to determine the limiting factors of the working capacity in men with a mean age of 70.7 years, the adaption of the central circulation to exercise was studied by right heart catheterization. In comparison to younger subjects at rest and in supine position, older men had an average 10 per cent lower oxygen consumption, 25 per cent higher arteriovenous oxygen difference, 30 per cent lower cardiac output, the same pulse rate, and 30 per cent lower stroke volume. During work in the supine position the increase in oxygen uptake was mainly the same as in young men. In the sitting position, at rest and during work, the cardiac output was lower and the arterio-venous oxygen difference higher than in the supine position. Stroke volume at rest in the sitting position was the same in both old and young groups, but increased less during transition to work in older subjects. At rest in the supine position, pulmonary capillary venous pressure and pulmonary arterial right ventricular and brachial arterial pressures were equal to those of younger men. The most significant findings during work were higher venous pressure and end diastolic pressures in the right ventricle.

18. Hermann, F. von

Prone flying. SAILPLANE AND GLIDER (LONDON) v. 20, n. 6, p. 5-6, June 1952.

Reports of various German pilots regarding their personal experience while piloting a plane in the prone position reveal that in no case major discomfort was encountered. A position between kneeling and lying prone, with the upper part of the body inclined at 30° to the horizontal proved to be the best posture. No fatigue was experienced even after flights lasting 6 to 10 hours. The range of vision was found to be considerably wider than in the sitting position. Only one pilot stated that the location of the head far ~~back~~ in front of the center of gravity of the aircraft, involved angular accelerations which were felt unpleasantly in acrobatic flying.

19. Hertzberg, H.T.E., Emanuel, I. and Alexander, M.

THE ANTHROPOMETRY OF WORKING POSITIONS.

I. A PRELIMINARY STUDY. U.S. Air Force.

Rept. no. WADC TR 54-520, Aug 56, 12p.

ASTIA AD 39 439

Measurements taken on forth adult males to ascertain new body-size data for various representative working positions. The positions include standing, kneeling, crawling, and prone positions.

20. Hertzberg, H.T.E. and Colgan, J.W.

A PRONE POSITION BED FOR PILOTS. U.S. Air Force. Headquarters Air Material Command, Engineering Division, Aero Medical Laboratory. Memorandum rept. no. MCREXD-695-71D, 25 June 48, 32p.

ASTIA ATI 34 088

21. Howard, P.

Physiological problems of space flight.

NEW SCIENTIST v. 10, n. 231, p. 106-108, Apr 1961.

Major problems of manned space flight, primarily acceleration, weightlessness, and deceleration, are discussed. Most of the data of the physiological effects of acceleration (including tolerance to various directions in which it acts on the body, symptoms created, effects on the circulatory system of increasing its intensity, and how to increase tolerance to increased g-intensity by assuming various body and head positions) have come from centrifuge studies. Knowledge concerning such problems as feeding, drinking and excreting waste products in the weightless state and the effects of weightlessness on the nervous system has been drawn from carefully controlled parabolic flights in which weightlessness has been produced for about 40 sec. Deceleration

21. (cont'd) has exactly the same properties and physiological effects as acceleration, and the same precautions must be taken to avoid exceeding its limits of tolerance. A discussion dealing with ways of keeping within deceleration tolerance limits during re-entry is presented.

22. Humphries, M.

Performance as a function of control-display relations, positions of the operator, and locations of the control.

JOURNAL OF APPLIED PSYCHOLOGY v. 42, n. 5, p. 311-316, Oct 1958.

To investigate the interaction between control-display relations, position of the control and position of the operator as they affect performance, 24 groups of male subjects practiced for five minutes on the Toronto Complex Coordinator. Each group worked on only one combination of control position, body orientation, and control-display relation. The results are given in the the number of matches made by each group and in terms of an analysis of variance of the effects of four tasks, three positions of the operator and two positions of the control.

23. Kunnapas, T.M.

Influence of head inclination on the vertical horizontal illusion. JOURNAL OF PSYCHOLOGY v. 46 (Second Half), p. 179-185, Oct 1958.

To investigate how the inclination of the head to the horizontal position influences the vertical-horizontal illusion, 20 subjects adjusted either the vertical or horizontal line of the test figure (an L) until it appeared equal to the standard horizontal line under two head position conditions--vertical and horizontal (85 degrees to the right). Six subjects also did this with the head inclined horizontally to the left. The data were examined by analysis of variance and the results were discussed in terms of previous findings by the author.

24. Lewis, B.M., et al

The effects of body position, ganglionic blockade and norepinephrine on the pulmonary capillary bed. JOURNAL OF CLINICAL INVESTIGATION v. 39, n. 9, p. 1345-1352, Sep 1960.

The pulmonary capillary blood volume (Vc) and the diffusing capacity of the pulmonary membrane (Dm) of normal subjects were calculated from measurements of diffusing capacity of the lungs for carbon monoxide in the recumbent and 45° head-up tilted positions during a control period and during the infusion of trimethapan (a ganglionic blocking agent) or norepinenephrine. Head-up tilting was observed to produce a fall in Vc, with no change in Dm. Infusion of trimethapan decreased Vc in the recumbent position and accentuated its decrease during tilting. Norepinephrine had no effect on Vc in the recumbent position, but abolished the decrease in Vc during tilting and increased Dm during recumbency. The changes observed in Vc were in the same direction as changes in calculated capillary transmural pressure. It is suggested that the capillary changes which occur during tilting, exercise, and during trimethapan infusion are passive responses of the capillary bed to changes in transmural pressure. The absence of an increase in capillary volume during norepinephrine infusion, when transmural pressure was probably increased, suggests the presence of an active vasomotion under some circumstances.

25. Moreno, F. and Lyons, H.A.

Effect of body posture on lung volumes. JOURNAL OF APPLIED PSYSIOLOGY 16, n. 1, p. 27-29, Jan 1961.

The changes produced by body posture on total lung capacity and its subdivisions have been reported for all positions except the prone position. Twenty normal subjects, twelve males and eight females, had determinations of total lung capacity in the three body positions, sitting, supine and prone. Tidal volume, minute ventilation and O_2 consumption were also measured. The changes found on assumption of the supine position from the sitting position were similar to those previously reported. For the prone position, a smaller inspiratory capacity and a larger expiratory reserve volume were found. The mean values were changed, respectively,--8% and +37%. Association with these changes was a significant increase of the functional residual capacity by 636 ml. Ventilation did not change significantly from that found during sitting, unlike the findings associated with the supine position, in which the tidal volume was decreased. Respiratory frequency remained the same for all positions.

26. Pierce, B.F. and Murch, K.R.
STRENGTH AND REACH ENVELOPES OF A PILOT WEARING A FULL-PRESSURE SUIT IN THE SEATED AND SUPINE POSITIONS.
Convair, San Diego. Rept. no. ZR-659-034, 23 July 59, 31p.

27. Pierce, B.F.
A technique for determining and representing the mobility envelope of a supine operator. PERCEPTUAL AND MOTOR SKILLS v. 11, n. 2, p. 215-219, Oct 1960.

The reach limitations of a supine operator were explored under simulated space flight conditions. The study employed a single subject with a functional reach of 29.6 in., clad in a light-weight, full-pressure, high-altitude suit. The suit was not inflated. The subject was harnessed in a semi-supine position to a specially constructed chair. Each reach point of the right arm was measured three-dimensionally from the side wall, the wall behind his head, and the floor. The data were then converted giving the location of each point along the mobility envelope (the space encompassed by the limits to which an individual can extend his arms and grasp objects in his hand) as a quantified distance from the Seat Reference Point (the point where the middle lines of the seat and the backrest intersect) in the vertical, lateral and longitudinal directions. A method of graphic representation of the mobility envelope was developed for a far more meaningful presentation of the data.

28. Reeves, J.T., et al
Circulatory changes in man during mild supine exercises. JOURNAL OF APPLIED PHYSIOLOGY v. 16, n. 2, p. 279-282, Mar 1961.

Cardiac output and femoral A-V oxygen difference were measured in each of seven normal men at rest and during several stints of supine exercise to

28. (cont'd) investigate the mechanisms of oxygen transport for stepwise increments of oxygen uptake. The femoral A-v oxygen difference increased sharply for mild exercise and showed smaller further increase for heavier exercise stints. The pulmonary A-v oxygen difference followed a similar behavior where the changes were of smaller magnitude. For mild exercise, increasing oxygen transport apparently depends to a greater extent on increasing flow and to a smaller extent on a widening tissue oxygen extraction. Mechanisms which are utilized to meet the increased metabolic demands of exercise depend in part upon the severity of the exertion. Cardiac output appears not to be a simple linear function of oxygen uptake for various metabolic demands ranging from rest to heavy exercise.

29. Schmidt, L.

Investigations of the prone position for pilots. ZENTRALE FUER WISSENSCHAFTLICHES BERICHTSWESEN DER LUFTFAHRTFORSCHUNG (BERLIN) UM 1297, 13 May 1944. (Trans. by K.H. Doetsche, Gt. Brit., Royal Aircraft Establishment. Library translation no. 396; DN-Aer; T.I. no. 56815, Jan 1952, 15+ 10p.

The "B.9" is a twin engine, cantilever, low-wing monoplane of composite construction, stressed for an ultimate factor of 22g. The pilot is placed in the fuselage nose. The bed on which the pilot lies is provided with fore and aft adjustment and an adjustable chin rest. There are arm rests, and the legs are slightly bent. A back parachute replaces the conventional chest-type parachute. Modified stick controls (in preference to wheel controls) are used. Brakes and rudder are controlled by the feet in the conventional manner. All secondary controls and switches are situated on the port side of the fuselage. The prone position was considered comfortable by the pilots. Fatigue was experienced by some in the nape of the neck and the shoulders. The chin rest was considered disturbing in horizontal flight. The relative position of the field of view, as compared to the seated position, shifted into a position with the main line of vision declined 30° below the horizon. Flight handling was not encountered difficult. The feeling of "suspension" was absent in the vertical dive. Maximum accelerations of 8.5 g in pullouts and 6 g in steep spirals were tolerated over several seconds.

30. Shepard, A.H. and Cook, T.W.

Body orientation and perceptual-motor performance. PERCEPTUAL AND MOTOR SKILLS v. 9, n. 3, p. 271-280, Sep 1959.

To investigate changes in performance of a particular control-display relation on the Toronto Complex Coordinator with systematic changes in body orientation during practice, six groups of ten male subjects each practiced for five successive five-minute periods at various combinations of four body positions. Performance (number of matches and number of errors per match in moving the control stick so as to light up a disc) measures were compared for the practice periods, and for body positions in pairs using t. The results are interpreted in terms of stimulus-response compatibility considering body position.

31. Steinkamp, G.R. and Hauty, G.T.

Simulated space flights. In Flaherty, B.E., ed. PSYCHOPHYSIOLOGICAL ASPECTS OF SPACE FLIGHT. New York, Columbia Univ. Press, p. 75-79, 1961.

The physiological and psychological responses of selected subjects exposed to 30-hour test periods in a space cabin simulator are described. Conditions of the experiment included restricted diet, restriction of movement, and the requirement of constant attention to a flight task. During the test period all subjects experienced psychological aberrations of some kind and in varying degree. Following exposure subjects exhibited the effects of accumulative fatigue, sleep deprivation, lowered caloric intake, and mild dehydration. The experiments indicate the need for pre-flight exposure to simulate space flight conditions and continued research with space cabin simulators.

32. Wang, Y., Marshall, R.J. and Shepherd, J.

The effect of changes in posture and of graded exercise on stroke volume in man. JOURNAL OF CLINICAL INVESTIGATION v. 39, n. 7, p. 1051-1061, July 1960.

32. (cont'd) Cardiac output, heart rate, and stroke volume were measured in four healthy males at rest in supine position, at rest standing, and during exercise in the upright position. Exercise varied from gentle movements of the calf muscles and marking time to walking at 4.5 m.p.h. up a treadmill inclined at 12 degrees from the horizontal. The cardiac index of subjects at rest in the supine position averaged 3.5 liters, and the stroke index averaged 54 ml. In the standing position, a fall in cardiac output (stroke index 32 ml.) and an increase in heart rate were observed. Moderate exercise restored the stroke index to the level obtained in the resting supine position; severe exercise increased the stroke index to 59 ml., with a cardiac output of 15-25 liters/min. It is probable that the apparent discrepancies in previous reports of the stroke volume changes occurring during exercise were due to variations on the circumstances (supine or standing posture) under which resting values for stroke volume were obtained rather than to inadequate techniques for measuring cardiac output.

33. Witkin, H.A.

Perception of body position and of the position of the visual field. PSYCHOLOGICAL MONOGRAPHS v. 63, n. 7, p. 1-46, 1949.

To investigate factors involved in perception of body and visual field position, several experiments were employed a tilting room-tilting chair apparatus were performed. These included: 1) judging body and room orientation during changing relations between body and field, 2) adjusting body or room position to true upright, 3) adjusting body position to upright with and without visual field, 4) judging body and room position and adjusting pointer to upright. Qualitative differences in performance including illness brought on by unstable visual field are discussed. Quantitative differences in performance are discussed as a function of the relative importance of visual and postural sensations.

34. Witkin, H.A. and Asch, S.E.

Studies in space orientation. III. Perception of the upright in the absence of a visual field. JOURNAL OF EXPERIMENTAL PSYCHOLOGY v. 38, n. 5, p. 603-614, Oct 1948.

34. (cont'd) To determine how the upright is established in the absence of a surrounding visual field, subjects in a completely darkened room adjusted a luminous rod to the horizontal (H) and vertical (V) while in each of four head and body positions: 1) head alone tilted (right and left), 2) whole body tilted (right and left) each at 42 and 28 degrees), 3) body horizontal (right and left side), 4) standing erect. Tables are presented of mean errors in degrees (H and V judgments combined), mean range in degrees (H judgments), and direction of errors (H and V judgments combined) for each head and/or body position. The effectiveness of postural factors as an adequate and stable basis for such judgments is discussed.

35. Witkin, H.A. and Asch, S.E.

Studies in space orientation. IV. Further experiments in perception of the upright with displaced visual fields. JOURNAL OF EXPERIMENTAL PSYCHOLOGY v. 38, n. 6, p. 762-782, Dec 1948.

To determine how perception of the upright is affected by position of a simple luminous visual frame (28 degrees right, 28 degrees left, erect) and body position (28 degrees left, erect), 53 adult subjects in a completely darkened room adjusted a luminous rod (set within the frame) to the horizontal and vertical for all above combinations. In supplementary experiments judgments were made for: 1) additional frame positions, 2) frame within a frame situations, 3) rod with and without a frame situations. All results are discussed in terms of amount and direction of errors as a function of articulation of the visual field.

36. Yamazaki, T.

Study on the response of the ophthalmic artery wave to dynamic action. I. Variations during postural alterations. JAPANESE DEFENSE FORCES MEDICAL JOURNAL v. 7, n. 5, p. 1-5, May 1960. (In Japanese. English abstract, p. 4-5)

36. (cont'd) Investigations were made of the ophthalmic artery responses to changes in posture in an effort to gain insight into the possible effects that positive and negative accelerations may have upon cerebral blood circulation. With the subject lying upon his back in a freely-tilting (up and down) bed, observations were made of variations in the curve of the ophthalmic artery wave during the following three positions: head-high (angle of tile: $+30^{o}$), horizontal, and head-low (angle of tilt: -30^{o}). As the postural alterations proceeded from head-high to head-low positions, two types of curves were observed: one in which the first elevation remained as the highest peak, and the other in which the highest peak was maintained by a second elevation. Subjects exhibiting the two-peak type of curve showed a large variation in pulse pressure and some abnormalities in the circulation.

AUTHOR INDEX